Loaded Scintillator (with an eye on the NH)

S. Biller

- There are very few approaches that have the potential to lead to a practical experiment with discovery-level sensitivity to the non-degenerate NH range
- Cost is an important axis, along with availability of isotope and, very likely, other physics capabilities to justify the cost
- Even beyond these practical aspects, significant R&D is still needed to advance current state-of-the-art **=> need to invest in this on all fronts!**
- Loaded scintillator is one promising looking technology…

Technology involves large-scale detectors with broad physics programme

As loading level/detector scale increases,
sensitivity is governed by the interplay between:

1) Internal backgrounds
2) 8B solar neutrinos
3) 2νββ "spillover" →

Because of energy resolution, it only makes sense to load ^{136}Xe or ^{130}Te

KamLAND-Zen is currently leading the way!

For NH sensitivity, ~100 tonne scale is required => ^{136}Xe too expensive and rare

Cost of Te ~ $40/kg, ^{130}Te fraction = 34.5% => isotope cost ~ $116k/tonne

current loading tech is ~$1-2 M/tonne

This is the motivation to see if an inexpensive, scalable technology using natural Te can be developed

→ SNO+ is, first and foremost, a prototype demonstrator for the general technology… which can also do some physics

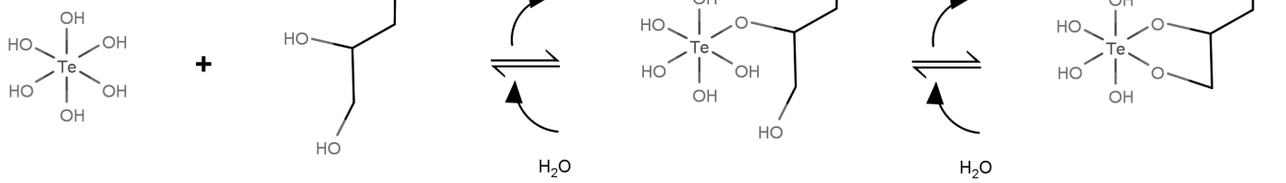
Should genuinely be taking the long view on a very difficult experimental problem that may have very limited (if any) avenues for success: support for development programmes aimed at potentially practical future NH technologies need to be an important part of the overall funding strategy!

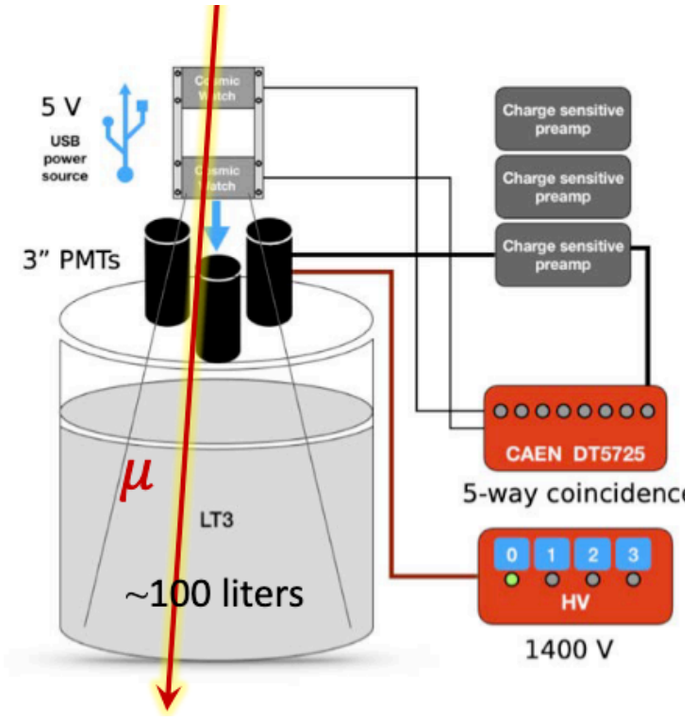
The basic target numbers for Te-loading to start looking like a serious NH experiment are: ~10% ^{nat}Te loading in ~10kT fid volume with ~1000 hits/MeV

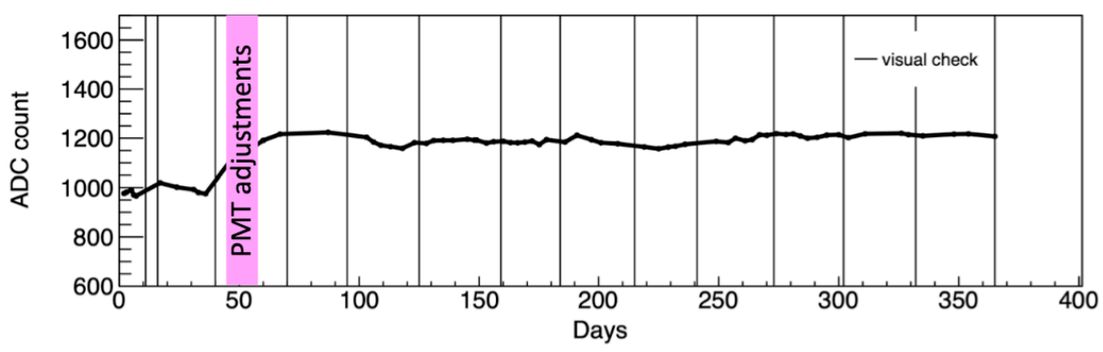
Not here yet, but significant progress on several development fronts…

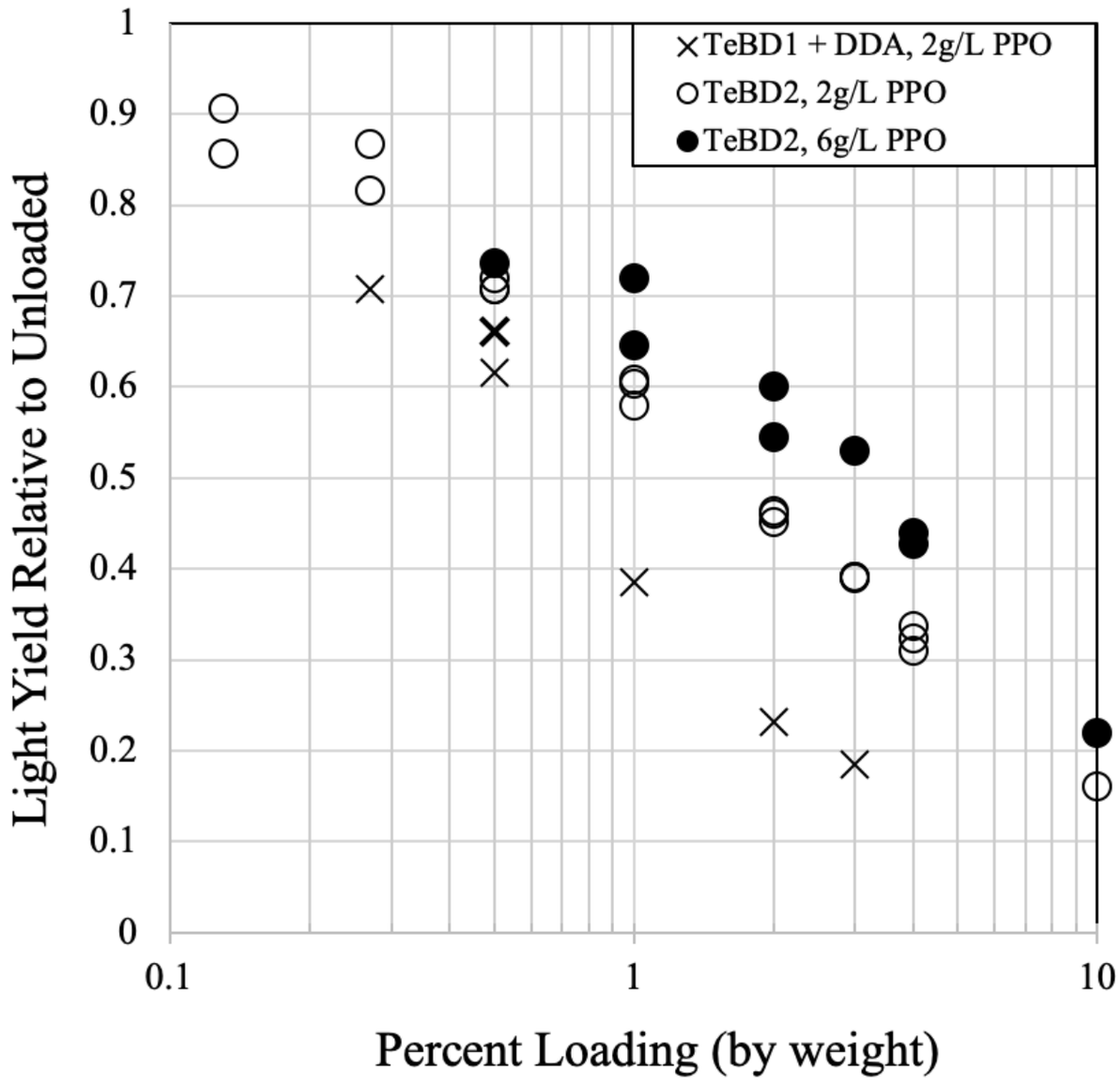
Te-Diol Loading in Liquid Scintillator

(paper in progress)









Multi-site event discrimination in large liquid scintillation detectors

(Dunger and Biller, NIM, **943**, 162420, 1 November 2019, arXiv:1904.00440)

Compton length for 1 MeV γ in LAB ~20cm, vs vertex resolution of ~10cm

use time residuals from vertex fit to form PDFs for a likelihood discriminant

In situ **calibration of technique**

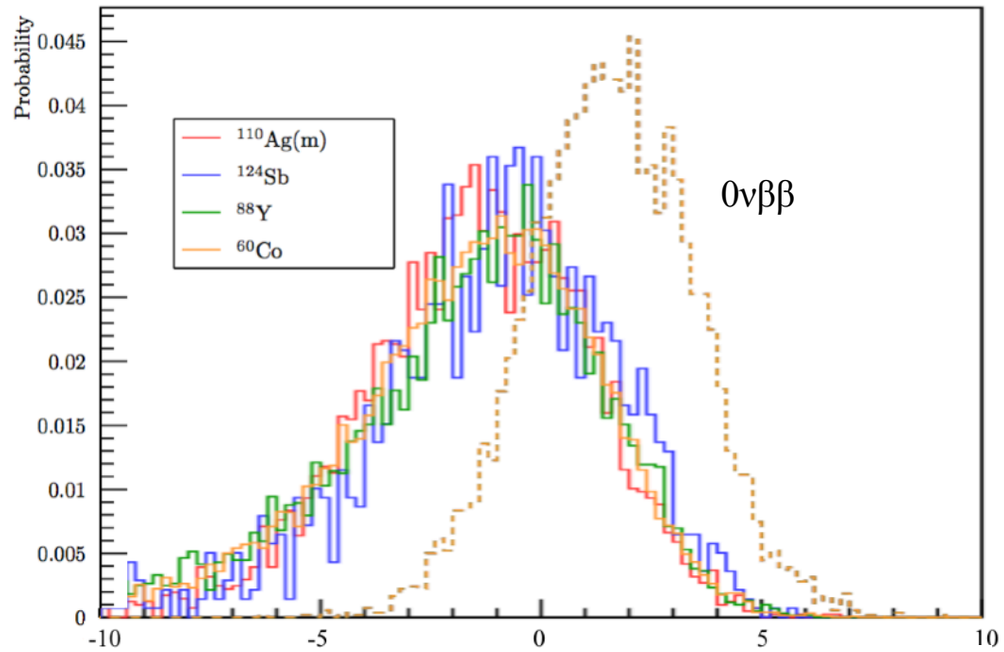
multi-site events:

- α-tagged ^{214}Bi & ^{208}Tl decays
- external γ's (dominant at higher radius)

single-site events:

- 2νββ events (dominant at lower energy)
- ^{8}B solar ν (dominant at higher energies)

can also use deployed sources

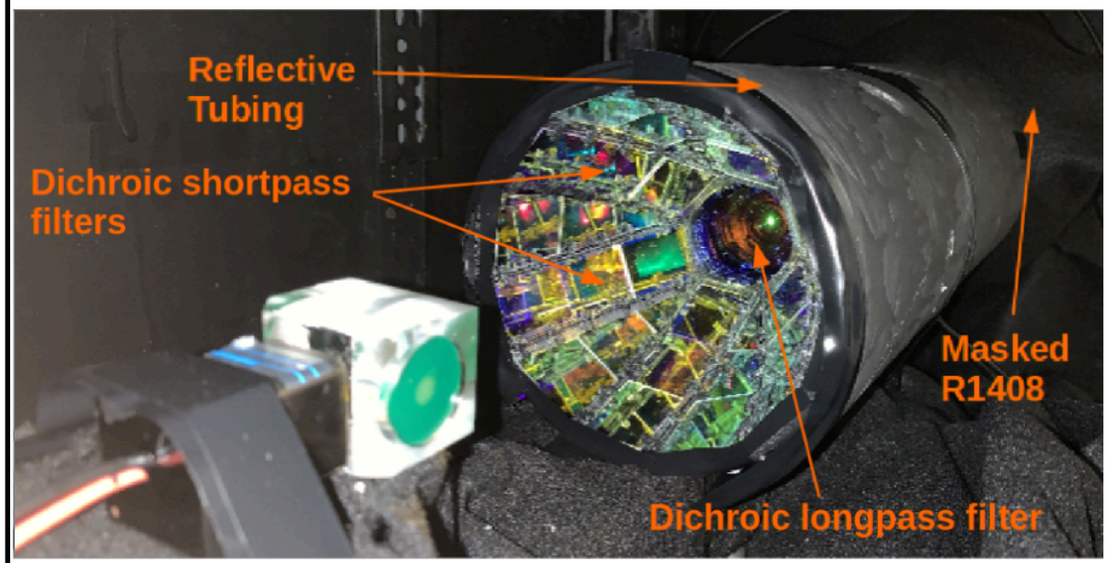


Can identify signal as distinct from cosmogenic background -> discovery experiment!

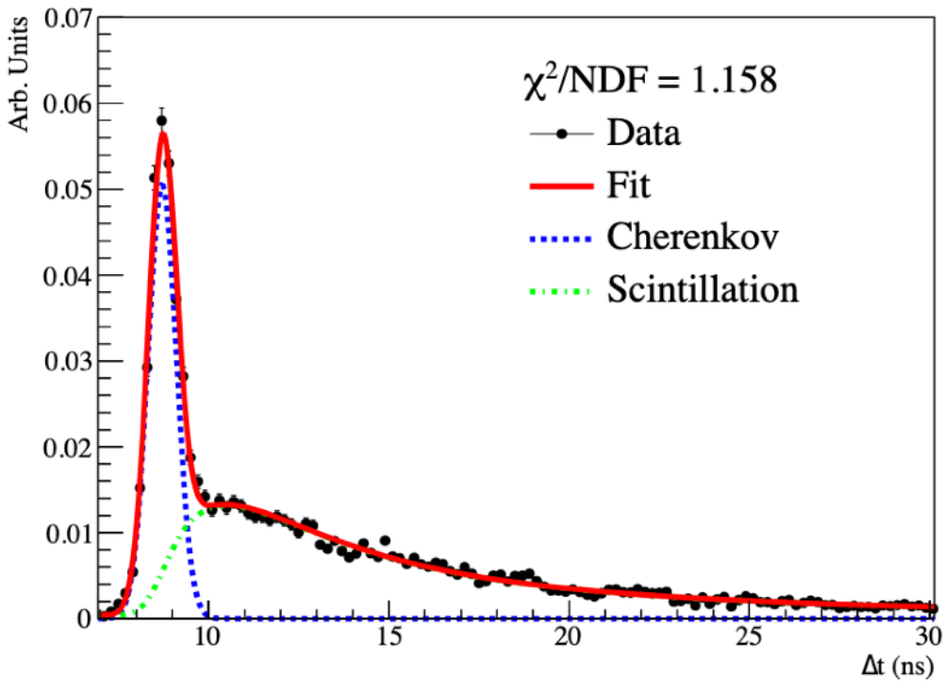
Cherenkov Separation

Could allow suppression of ^{8}B background and potentially provide topological information to test 0νββ mechanism

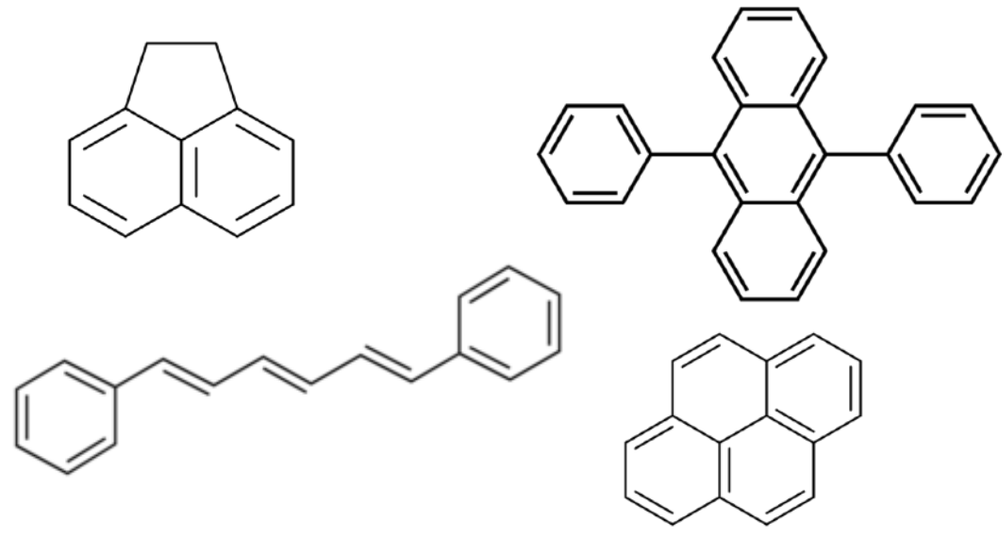
Dichroic Concentrators



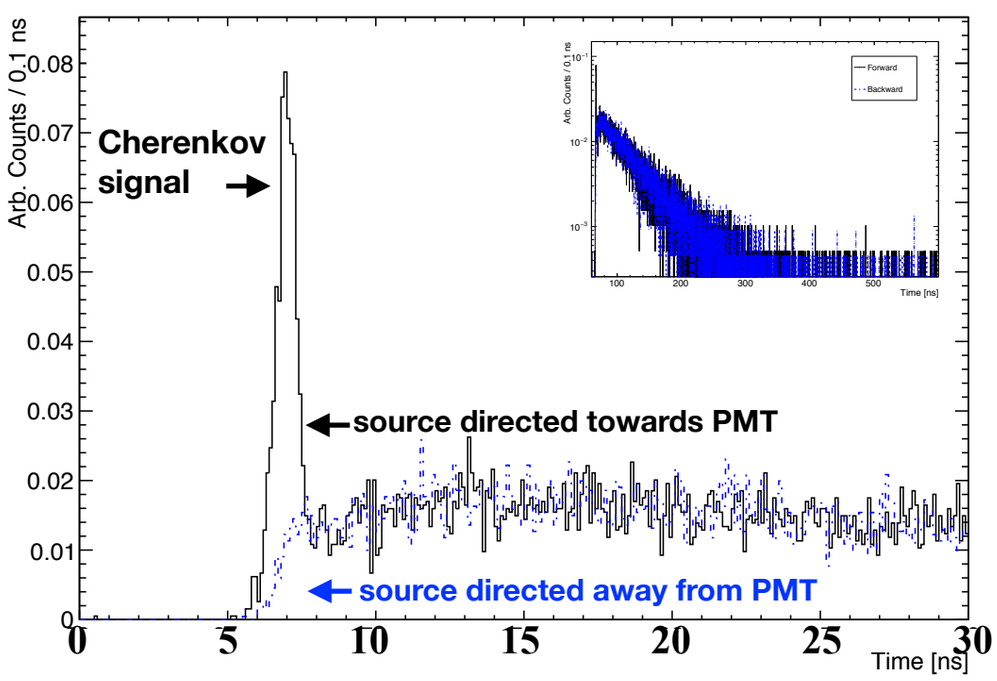
Kaptanoglu, Luo, Land, Bacon & Klein - arXiv:1912.10333



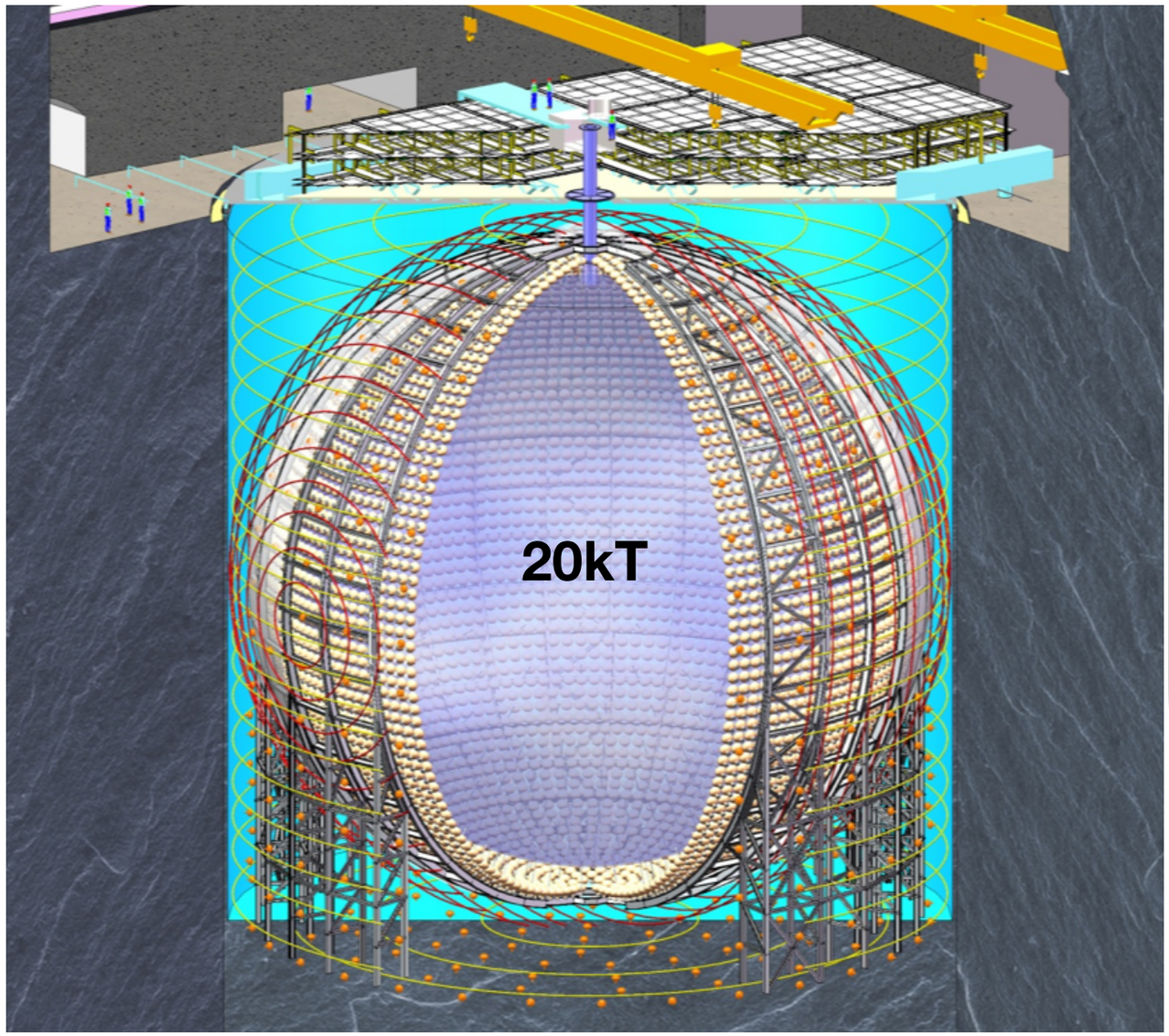
Slow Fluors



Biller, Leming & Paton - arXiv:2001.10825



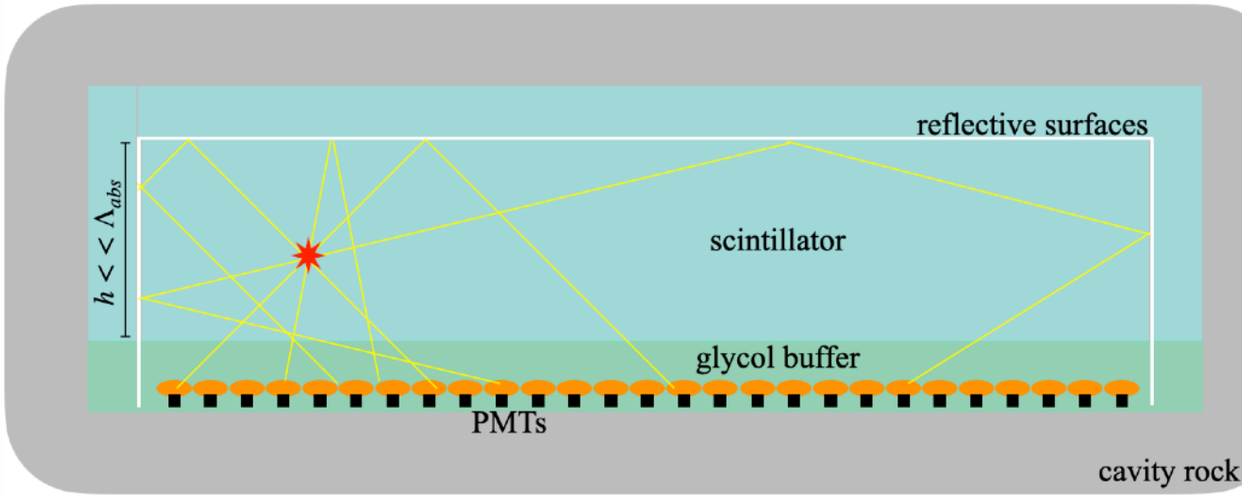
Possible Future of Te-Loaded Scintillator:



Exploring possible future deployment of Te in JUNO

(or perhaps THEIA, or perhaps some other similar scale of instrument)

SLIPS concept (see LoI)



Exploring new design geometries for more economical and efficient large scale detectors